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# Nd-Doped Laser Glass Spectroscopic and Physical Properties

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# Nd-Doped Laser Glass Spectroscopic and Physical Properties

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Original Issue  
November 1978

September 1978

Current status: Research sample  
 Melt: K-824, December 1976

## COMPOSITION

Compound	Mole %	Weight %
Ta <sub>2</sub> O <sub>5</sub>	17.0	56.79
MgO	31.5	9.6
SiO <sub>2</sub>	38.0	17.26
BaO	13.0	15.07
Nd <sub>2</sub> O <sub>3</sub>	0.5	1.27

Measured neodymium concentration	-	wt % Nd <sub>2</sub> O <sub>3</sub>
Neodymium number density $\rho_N$	$2.378 \times 10^{20}$	cm <sup>-3</sup>

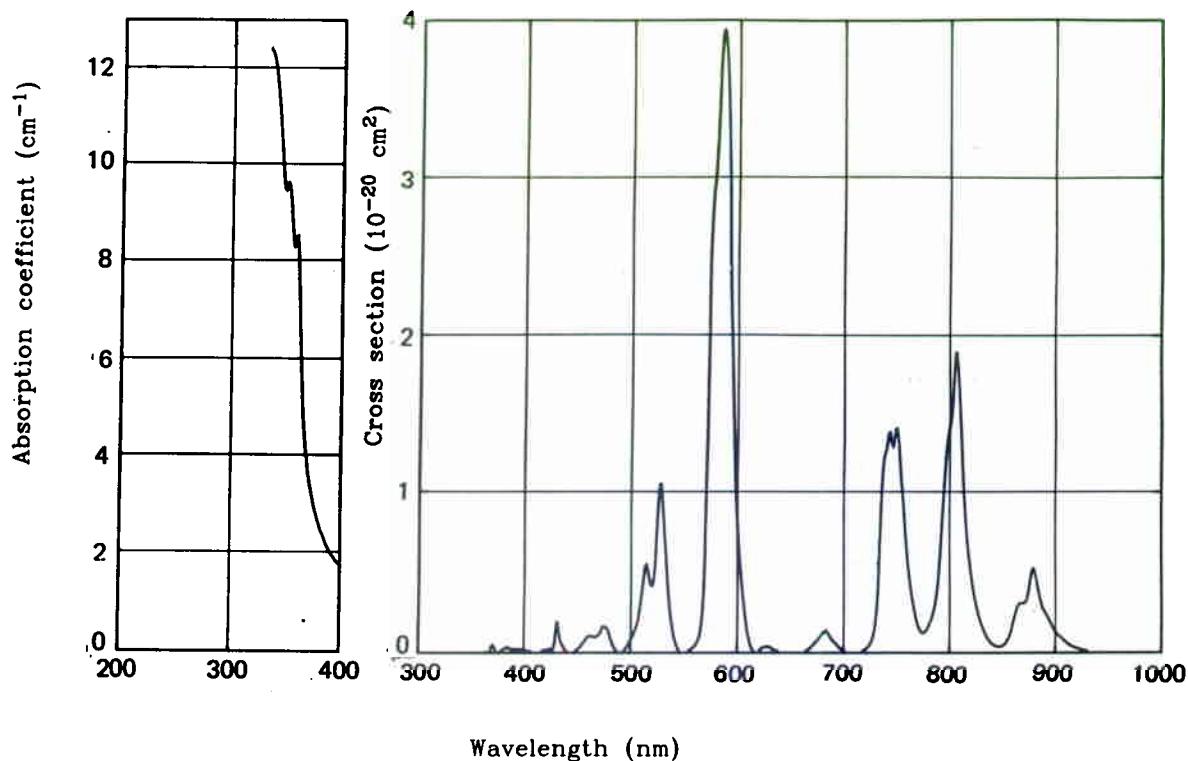
Compositional series:

## PROPERTY SUMMARY

Peak stimulated emission cross section	$\sigma_p$	$2.4 \times 10^{-20}$	cm <sup>2</sup>
Calculated radiative lifetime	$\tau_R$	2.74	μsec
Zero-concentration lifetime	$\tau_0$	-	μsec
Nd <sup>3+</sup> concentration @ $\tau_0/2$	Q	-	cm <sup>-3</sup>
Nonlinear refractive index coefficient	$\gamma$	$8.48 \times 10^{-20}$	m <sup>2</sup> ·W <sup>-1</sup>
Nonlinear refractive index	$n_2$	$3.44 \times 10^{-13}$	esu
Refractive index at peak-fluorescence wavelength	$n(\lambda_p)$	1.70327	
Peak-fluorescence wavelength	$\lambda_p$	1064.5	nm
Linewidth (FWHM)	$\Delta\lambda$	38.20	nm
Linewidth (effective)	$\Delta\lambda_{eff}$	42.64	nm
Density	$\rho$	5.23	g·cm <sup>-3</sup>

September 197

## ABSORPTION PROPERTIES



Integrated absorption cross section relative  
to ED-2 from 400 to 950 nm                    1.32

Absorption efficiency coefficients for 15-mm  
xenon flashlamp at  $1000 \text{ A} \cdot \text{cm}^{-2}$   
(400 to 940 nm):

$$\epsilon = A [1 - B \exp(-C\rho_N l) - (1-B) \exp(-D\rho_N l)] \quad \left. \right\}$$

where  $\rho_N l$  is in  $10^{20} \text{ Nd ions} \cdot \text{cm}^{-2}$

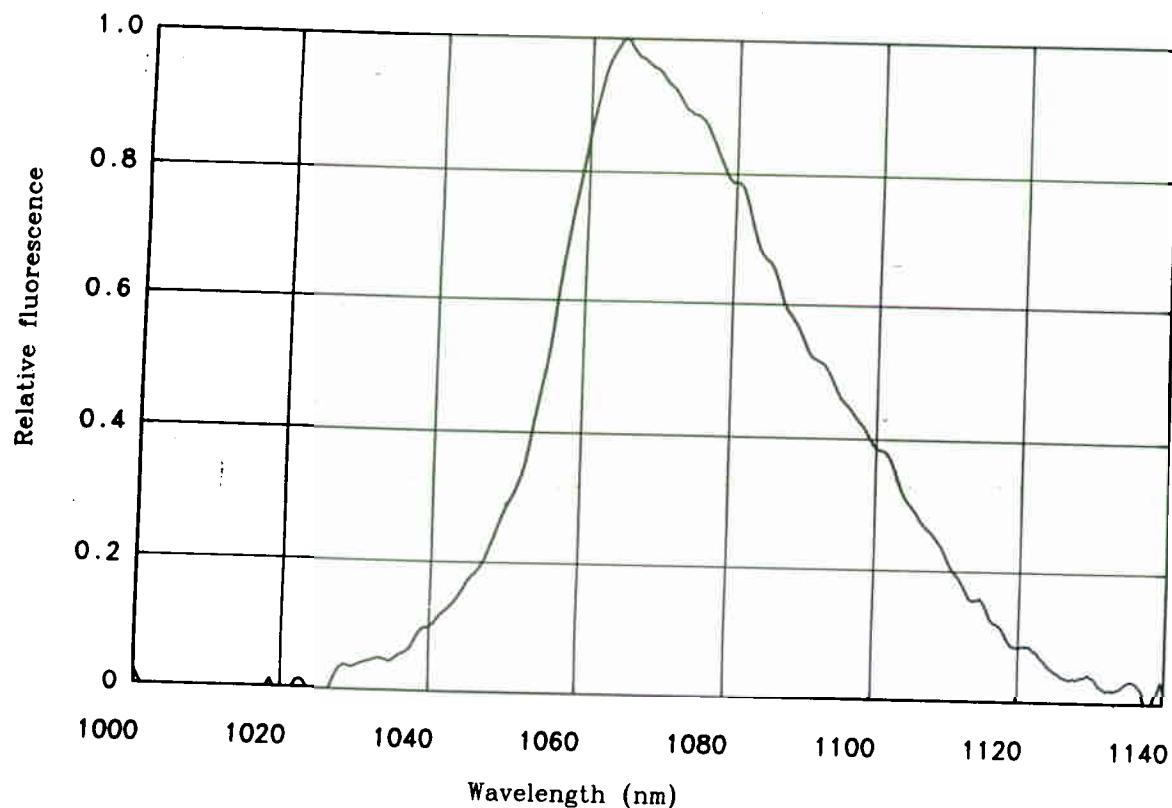
$$\begin{aligned} A &= 0.109258 & B &= 0.691330 \\ C &= 0.154631 & D &= 1.328205 \text{ cm}^2 \end{aligned}$$

Judd-Ofelt parameters:

$\Omega_2$	$7.0 \pm 0.3 \times 10^{-20}$	$\text{cm}^2$
$\Omega_4$	$4.6 \pm 0.4 \times 10^{-20}$	$\text{cm}^2$
$\Omega_6$	$4.7 \pm 0.2 \times 10^{-20}$	$\text{cm}^2$

September 1978

## FLUORESCENCE PROPERTIES



Peak-fluorescence wavelength

 $\lambda_p$ 

1064.5

nm

Linewidth (FWHM)

 $\Delta\lambda$ 

38.20

nm

Linewidth (effective)

 $\Delta\lambda_{eff}$ 

42.64

nm

Peak stimulated emission cross section

 $\sigma_p$  $2.4 \times 10^{-20}$ cm<sup>2</sup>

Calculated radiative lifetime

 $\tau_R$ 

274

μsec

Zero-concentration lifetime

 $\tau_0$ 

-

μsec

Nd<sup>3+</sup> concentration @  $\tau_0/2$ 

Q

-

cm<sup>-3</sup>

Branching ratios:

 $(^4F_{3/2} \rightarrow ^4I_J) J = 9/2, 11/2, 13/2, 15/2$ 

0.430, 0.477, 0.090, 0.004

Measured decay properties: three e-folding times 190, 214, 230 μsec

Decay function:  $I/I_0 = A \exp(-Bt) + C \exp(-Dt) + E \exp(-Ft)$ 

A = -	B = -	$\text{sec}^{-1}$
C = -	D = -	$\text{sec}^{-1}$
E = -	F = -	$\text{sec}^{-1}$

September 1978

**OPTICAL PROPERTIES**

Refractive index at sodium D line	$n_D$	1.72	
Refractive index at peak fluorescence	$n(\lambda_p)$	1.70327	
Abbe number, $(n_D - 1)/(n_F - n_C)$	$\nu$	45.0	
Index temperature coefficient	$\partial n/\partial T$	-	$^{\circ}\text{C}^{-1}$
Thermal coefficient of optical path length	$\partial s/\partial T$	-	$^{\circ}\text{C}^{-1}$
Nonlinear refractive index coefficient	$\gamma$ calc	$8.48 \times 10^{-20}$	$\text{m}^2 \cdot \text{W}^{-1}$
Nonlinear refractive index	$\gamma$ meas	-	$\text{m}^2 \cdot \text{W}^{-1}$
	$n_2$ calc	$3.44 \times 10^{-13}$	esu
Stress optic coefficient	$n_2$ meas	-	esu
	$\Delta B$	-	$\text{nm} \cdot \text{cm} \cdot \text{kg}^{-1}$

**THERMAL PROPERTIES**

Thermal expansion coefficient	$\alpha$	-	$^{\circ}\text{C}^{-1}$
Specific heat at constant pressure	$C_p$	-	$\text{J} \cdot \text{cm}^{-3} \cdot ^{\circ}\text{C}^{-1}$
Thermal heat conductivity	$\kappa$	-	$\text{W} \cdot \text{m}^{-1} \cdot ^{\circ}\text{C}^{-1}$
Softening point	$T_y$	-	$^{\circ}\text{C}$
Transformation point	$T_g$	-	$^{\circ}\text{C}$

**MECHANICAL PROPERTIES**

Density	$\rho$	5.23	$\text{g} \cdot \text{cm}^{-3}$
Knoop hardness	$K_H$	-	$\text{kg} \cdot \text{mm}^{-2}$
Young's modulus	$E$	-	$\text{kg} \cdot \text{mm}^{-2}$
Shear modulus	$G$	-	$\text{kg} \cdot \text{mm}^{-2}$
Poisson ratio	$\sigma$	-	

**SOLUBILITY**

Stability in water	-
Stability in acid	-

**REFERENCES and NOTES**

August 1978

Current status: Research sample  
 Melt: EK-2236, 1973

## COMPOSITION

Compound	Mole %	Weight %
$\text{Bi}_2\text{O}_3$	24.21	60.0
$\text{CdO}$	43.93	30.0
$\text{SiO}_2$	31.29	10.0
$\text{Nd}_2\text{O}_3$	0.56	1.0

Measured neodymium concentration	-	wt % $\text{Nd}_2\text{O}_3$
Neodymium number density $\rho_N$	$2.403 \times 10^{20}$	$\text{cm}^{-3}$

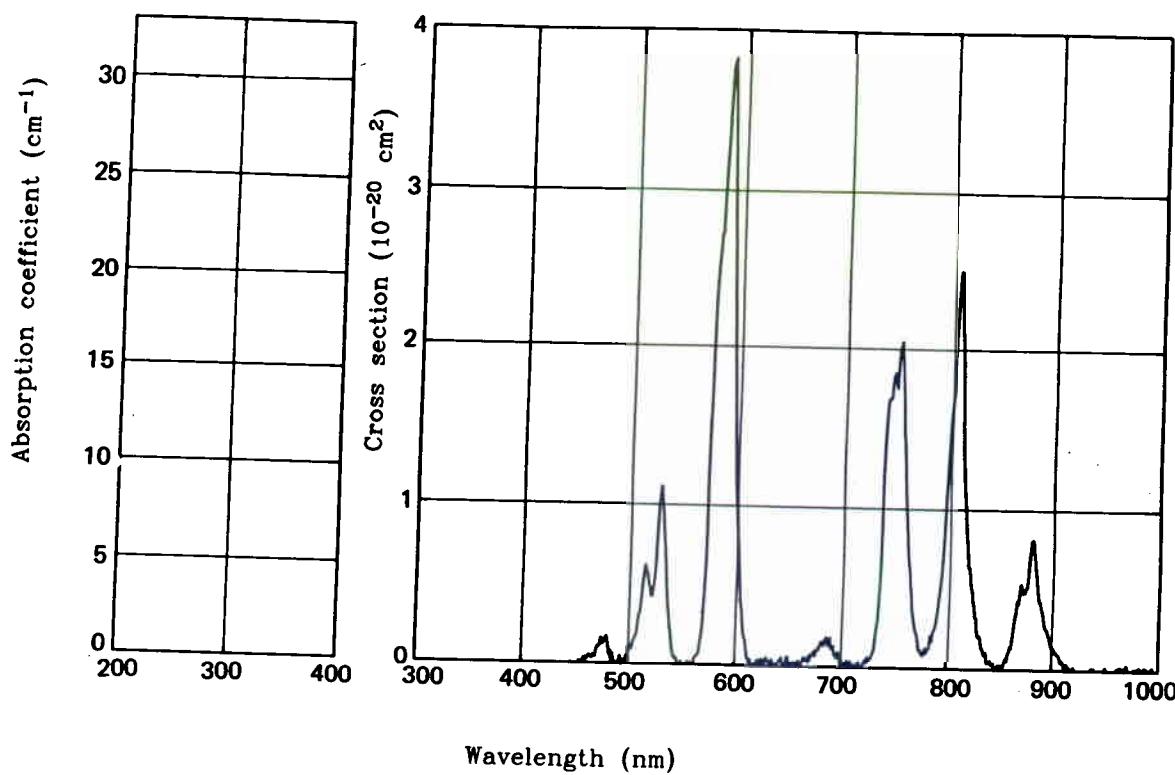
Compositional series:

## PROPERTY SUMMARY

Peak stimulated emission cross section	$\sigma_p$	$3.6 \times 10^{-20}$	$\text{cm}^2$
Calculated radiative lifetime	$\tau_R$	234	$\mu\text{sec}$
Zero-concentration lifetime	$\tau_0$	-	$\mu\text{sec}$
$\text{Nd}^{3+}$ concentration @ $\tau_0/2$	Q	-	$\text{cm}^{-3}$
Nonlinear refractive index coefficient	$\gamma$	$15.6 \times 10^{-20}$	$\text{m}^2 \cdot \text{W}^{-1}$
Nonlinear refractive index	$n_2$	$6.29 \times 10^{-13}$	esu
Refractive index at peak-fluorescence wavelength	$n(\lambda_p)$	1.69492	
Peak-fluorescence wavelength	$\lambda_p$	1063.5	nm
Linewidth (FWHM)	$\Delta\lambda$	28.43	nm
Linewidth (effective)	$\Delta\lambda_{\text{eff}}$	34.57	nm
Density	$\rho$	6.711	$\text{g} \cdot \text{cm}^{-3}$

August 1978

## ABSORPTION PROPERTIES



Integrated absorption cross section relative  
to ED-2 from 400 to 950 nm

1.41

Absorption efficiency coefficients for 15-mm  
xenon flashlamp at  $1000 \text{ A} \cdot \text{cm}^{-2}$   
(340 to 940 nm):

$$\epsilon = A [1 - B \exp(-C\rho_N l) - (1-B) \exp(-D\rho_N l)] \quad \left. \begin{array}{l} \\ \end{array} \right\} \quad \begin{array}{ll} A = 0.110933 & B = 0.669260 \\ C = 0.159280 & D = 1.365418 \text{ cm}^2 \end{array}$$

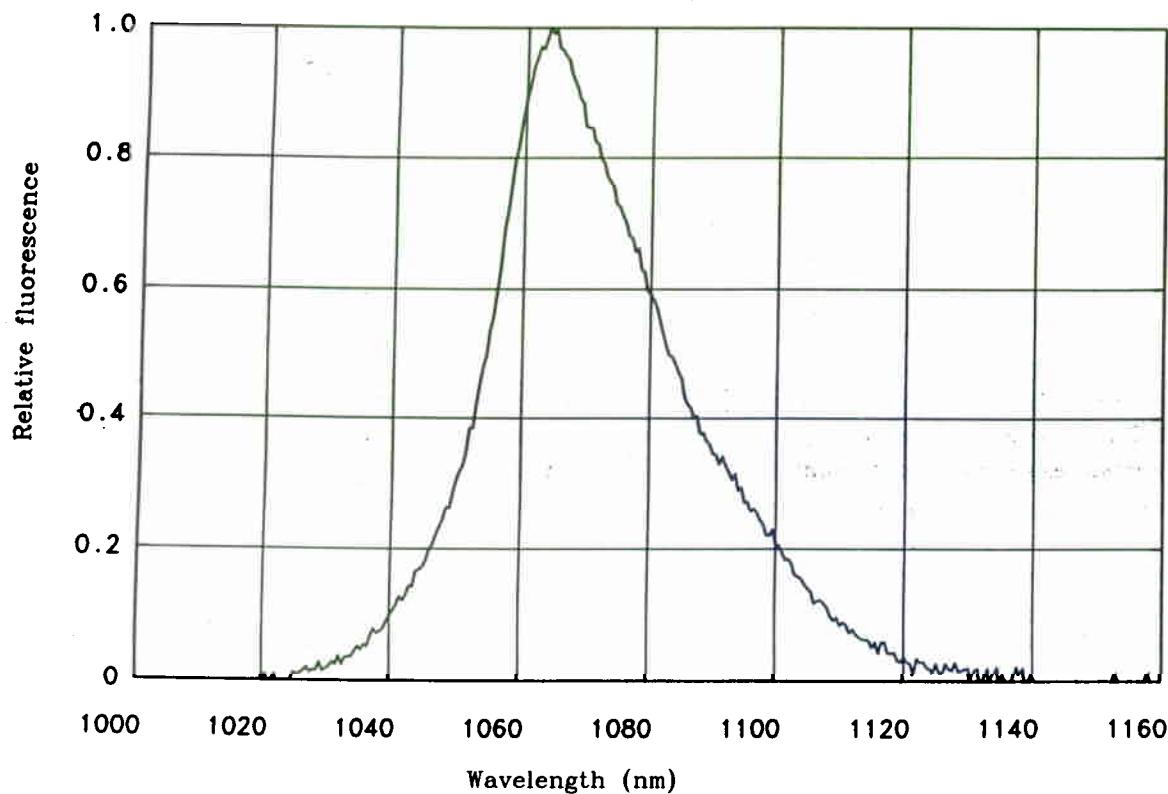
where  $\rho_N l$  is in  $10^{20} \text{ Nd ions} \cdot \text{cm}^{-2}$

Judd-Ofelt parameters:

$\Omega_2$	$5.4 \pm 0.3 \times 10^{-20}$	$\text{cm}^2$
$\Omega_4$	$5.1 \pm 0.5 \times 10^{-20}$	$\text{cm}^2$
$\Omega_6$	$5.9 \pm 0.2 \times 10^{-20}$	$\text{cm}^2$

August 1978

## FLUORESCENCE PROPERTIES



Peak-fluorescence wavelength	$\lambda_p$	1063.5	nm
Linewidth (FWHM)	$\Delta\lambda$	28.43	nm
Linewidth (effective)	$\Delta\lambda_{eff}$	34.57	nm
Peak stimulated emission cross section	$\sigma_p$	$3.6 \times 10^{-20}$	cm <sup>2</sup>
Calculated radiative lifetime	$\tau_R$	234	$\mu$ sec
Zero-concentration lifetime	$\tau_0$	—	$\mu$ sec
Nd <sup>3+</sup> concentration @ $\tau_0/2$	Q	—	cm <sup>-3</sup>

## Branching ratios:

$$(4F_{3/2} \rightarrow 4I_J) J = 9/2, 11/2, 13/2, 15/2 \quad 0.411, 0.490, 0.095, 0.005$$

Measured decay properties: three e-folding times      136, 161, 156       $\mu$ sec

Decay function:  $I/I_0 = A \exp(-Bt) + C \exp(-Dt) + E \exp(-Ft)$

A = —	B = —	$\text{sec}^{-1}$
C = —	D = —	$\text{sec}^{-1}$
E = —	F = —	$\text{sec}^{-1}$

August 1978

**OPTICAL PROPERTIES**

Refractive index at sodium D line	$n_D$	1.72	
Refractive index at peak fluorescence	$n(\lambda_p)$	1.69492	
Abbe number, $(n_D - 1)/(n_F - n_C)$	$\nu$	30	
Index temperature coefficient	$\partial n/\partial T$	-	$^{\circ}\text{C}^{-1}$
Thermal coefficient of optical path length	$\partial s/\partial T$	-	$^{\circ}\text{C}^{-1}$
Nonlinear refractive index coefficient	$\gamma$ calc	$15.6 \times 10^{-20}$	$\text{m}^2 \cdot \text{W}^{-1}$
	$\gamma$ meas	-	$\text{m}^2 \cdot \text{W}^{-1}$
Nonlinear refractive index	$n_2$ calc	$6.29 \times 10^{-13}$	esu
	$n_2$ meas	-	esu
Stress optic coefficient	$\Delta B$	-	$\text{nm} \cdot \text{cm} \cdot \text{kg}^{-1}$

**THERMAL PROPERTIES**

Thermal expansion coefficient	$\alpha$	-	$^{\circ}\text{C}^{-1}$
Specific heat at constant pressure	$C_p$	-	$\text{J} \cdot \text{cm}^{-3} \cdot ^{\circ}\text{C}^{-1}$
Thermal heat conductivity	$\kappa$	-	$\text{W} \cdot \text{m}^{-1} \cdot ^{\circ}\text{C}^{-1}$
Softening point	$T_y$	-	$^{\circ}\text{C}$
Transformation point	$T_g$	-	$^{\circ}\text{C}$

**MECHANICAL PROPERTIES**

Density	$\rho$	6.711	$\text{g} \cdot \text{cm}^{-3}$
Knoop hardness	$K_H$	-	$\text{kg} \cdot \text{mm}^{-2}$
Young's modulus	$E$	-	$\text{kg} \cdot \text{mm}^{-2}$
Shear modulus	$G$	-	$\text{kg} \cdot \text{mm}^{-2}$
Poisson ratio	$\sigma$	-	

**SOLUBILITY**

Stability in water	-
Stability in acid	-

**REFERENCES and NOTES**